Acta arachnol., **45** (2): 147–150, December 30, 1996

Influence of Prey Species on the Supercooling Ability of the Redback Spider, *Latrodectus hasseltii* (Araneae: Theridiidae)

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田中　一裕[1)2)]・渡辺　匡彦[1)]：セアカゴケグモの過冷却点に及ぼす餌種の影響

Abstract Influence of prey animals on the supercooling ability of the redback spider, *Latrodectus hasseltii*, was examined. Supercooling points (SCPs) of this spider varied widely according to the prey items. The spiders fed laboratory-cultured insects were lower in SCPs than those supplied with field-collected ants. This suggests that the field-collected animals have efficient ice nucleators compared to the laboratory-reared animals. However, the correlation in supercooling points between the spiders and prey species was not perfect. This would be in part due to differences in quality or/and quantity of ice nucreators derived from prey species.

Introduction

One of the clear-cut relationship in arthropod cold hardiness is the action of gut contents on the reduction of supercooling ability (CANNON & BLOCK, 1988). In general, the individuals having gut contents have a poor supercooling capacity than those with empty gut (*e.g.* SALT, 1953; SOMME & CONRADI-LARSEN, 1977; BLOCK, 1982; SOMME & BLOCK, 1982; TSUMUKI & KONNO, 1991).

In some species, however, not only the presence of gut contents, but also its quality influence their supercooling ability (SOMME & BLOCK, 1982; GASH & BALE, 1985; TANAKA, 1994). In the house spider, *Achaearanea tepidariorum*, for example, its supercooling point (SCP), the temperature at which spontaneous freezing occurs, varies according to the prey animals consumed (TANAKA, 1994). It is low when spiders have fed on prey animals with low SCPs, but is high when they have fed on prey animals with high SCPs. This appears to suggest that the unidentified ice nucleating agents (INAs) present in the prey animals are transferred to the spiders through feeding and also act as potential seeds of ice crystals in their alimentary canal (TANAKA, 1994).

The aim of this study is to confirm whether the variable ice nucleating activity of prey animals occurs in other spider species. In the winter of 1996, we had an opportunity to rear the redback spider, *Latrodectus hasseltii*, an introduced poisonous spider

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Accepted December 12, 1996

recently found in Osaka and Mie Prefecture (NISHIKAWA, 1995). Here, we compare SCPs of the redback spider fed various prey animals and discuss the possible mechanism by which prey species influence the ability of spiders to supercool.

Materials and Methods

Each spiderling of *L. hasseltii* was cultured in a glass tube (15 mm in diameter and 70 mm in height) plugged with cotton wool and was kept at 25°C under LD 16:8 photoperiod. Each individual was daily fed an adult of *Drosophila melanogaster* during the first two stadia and five flies during the rest nymphal stadia.

In SCP experiments, 72–75 day old female nymphs of the final stadium were given one of the selected prey species and their SCPs were measured one day later. The prey animals used were *D. melanogaster* (control), the common armyworm *Mythimna separata*, the clover leaf weevil *Hypera punctata*, a cockroach *Periplaneta japonica* and an apterous ant *Formica japonica*. Except for *F. japonica*, they were cultured in the laboratory.

To determine the SCPs, each spider or prey animal was put into a test tube (10 mm in diameter and 40 mm in height) in which the specimen was in contact with the tip of a thermocouple connecting to a computer (PC-9801F). The test tube was covered twofold by a glass vial (30 mm in diameter and 65 mm in height) and a plastic vial (60 mm in diameter and 100 mm in height) to reduce the cooling rate to approx. 1°C/min in a freezer (*ca.* −24°C). The SCP was determined by the release of the latent heat due to ice formation within the body (LEE 1989).

Results and Discussion

The SCPs of the redback spider varied significantly with the prey species consumed (ANOVA, $F=16.8$, $P<0.001$; Table 1). The mean SCP was the lowest (*ca.* −15°C) when spiders fed on *D. melanogaster*, and the highest (*ca.* −6°C) when they fed on *F. japonica*. This indicates that the supercooling ability of the redback spider was strongly influenced by the gut contents. This is in agreement with the previous results obtained with the house spider (TANAKA, 1994), but contradicts the general inference about the spider cold hardiness that the gut contents are not likely to influence the supercooling ability, because the food particles that might act as ice nucleators are filtered out through the feeding process (KIRCHNER, 1987).

Among the prey species tested, *F. japonica* was the only species collected from the field, thus at least conforming to the previous observations by TANAKA (1994) that field-collected animals are more effective in reducing the spider's supercooling ability than laboratory-cultured animals. These results may suggest that field-collected prey animals contain some efficient ice nucleators that laboratory-reared animals do not have. If this is the case, the former would have higher SCPs than the latter.

A comparison of SCPs between the prey animals and spiders indicated that the supercooling ability of *L. hasseltii* partly depended on the presence of INAs in the prey species. *D. melanogaster*, which was less effective in reducing the spider's supercooling ability, had a very low SCP (*ca.* −17°C), thus indicating the possibility that it is a nucleator free. Because of the absence of INAs, spiders feeding on this fruit fly might have retained a relatively low SCP. On the other hand, *F. japonica*, being the most

Table 1. Supercooling point ± s.d. (°C) of prey species and the spiders, *Latrodectus hasseltii*, 24 h after feeding on different prey animals. Spiders were first reared with *Drosophila melanogaster*, and then fed various prey species 24 h before SCP determination. Sample size are in parenthesis.

Prey species (stage)	Supercooling point (°C)	
	Prey	Spider
Laboratory prey		
Drosophila melanogaster (adult)	−16.7±1.5 (10)a*	−15.0±0.8 (5)x
Mythimna separata (larva)	−10.3±1.0 (5)b	−10.9±2.0 (5)y
Hypera punctata (larva)	−6.5±0.2 (5)c	−11.4±1.1 (5)y
Periplaneta japonica (nymph)	−6.2±0.5 (5)c	−11.7±2.1 (5)y
Field prey		
Formica japonica (adult)	−8.0±1.4 (6)c	−6.3±1.1 (5)z

*Means followed by the same letter are not significantly different ($P<0.05$, Duncan's multiple range test).

effective in reducing the spider's SCP, had the highest SCP (*ca.*−8°C) among the prey species, suggesting that this ant contains highly efficient ice nucleators.

However, the relationship between the supercooling ability of prey items and their effect on the predator's supercooling ability is not perfect. *H. punctata* and *P. japonica*, for example, were similar to *F. japonica* in supercooling ability, although the former had relatively little effect on the spider's SCP after being consumed (Table 1). This may suggest a differential incorporation of INAs by the spider; INAs of *H. punctata* and *P. japonica* are partly incorporated by the spider, whereas those of *F. japonica* are more incorporated. Another possibility is that different species have different INAs which work differently when ingested by predators. Although further confirmation is necessary, it seems that such possibilities may at least in part explain the differential action of prey species on the supercooling ability of the predator.

Acknowledgements

We thank Yoshiaki NISHIKAWA, Otemon Gakuin University, and Maroko MYOHARA, National Institute of Sericultural and Entomological Science, for supplying *L. hasseltii* and *D. melanogaster*, respectively. Thanks are also due to Nobuo MORIMOTO, National Institute of Agro-environmental Science, for providing facilities for SCP determination. The manuscript was critically read by Kimio SHIMADA, Institute of Low Temperature Science, Hokkaido University and Seiji TANAKA, National Institute of Sericultural and Entomological Science.

摘　　要

セアカゴケグモの過冷却点(SCP)は餌種によって異なった．このことは消化管内容物が何らかの形でクモのSCPに影響することを示唆している．餌種とクモの過冷却点の比較から，餌種のクモの過冷却点に対する効果の違いは，餌種体内の氷核活性物質(INAs)の有無だけでなく，その質や取り込まれやすさの違いに起因していることが示唆された．

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